MISSION DESIGN FOR A DISCOVERY MARS GLIDERS MISSION IN 2003*

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ABSTRACT

There are many ways to explore Mars. Orbiters and landers, with rovers, provide a global view, and limited surface access. Other ways include penetrators, probes, balloons, gliders, planes, sample returns and, of course, human explorers. We can expect most of these methods to be used in the future, and each does have a unique advantage. This paper presents the trajectory related aspects of a mission design for a low cost Discovery mission which will deliver several gliders to the Valles Marineris canyon region of Mars in 2003.

Why gliders? The reason is that they have the right characteristics for a low cost mission. For a science payload of 1 kg which could consist of several remote sensors as well as imaging, they can be very light weight, say 15-25 kg. Also, they can be designed and tested in the upper atmosphere of the Earth; and require no propulsion; with the Martian atmosphere providing maneuverability, lift, temperature control, and stability. Also helpful is that light weight glider technology is an active field, pursued by Aerovironment for example. At Mars, imaging and spectral measurements can be made of the stratigraphic layers in the canyon walls in close proximity for tens of kilometers. Glider flight time would be limited to 10-15 minutes during which time data would have to be returned to the carrier, and from there transmitted back to Earth.

This mission poses some challenging mission design questions which must be explored. First, with the Discovery cost cap, is there a low-cost launch mode which can be used for such a small payload? Then, what Earth-Mars trajectory will minimize the carrier propellant requirements, and deliver the gliders to the desired location on Mars, and with acceptable lighting conditions? Finally, what would be the best mode to return the science data: use the carrier as a relay, or depend on an in-place Mars orbiter to relay the data? These questions are resolved in the paper, the first of which will be described briefly in this abstract.

Obviously, the way to minimize launch costs is to ride as a secondary payload on another mission. A specific launch mode has been developed by this author (Ref. 1) which uses the Ariane Structure for Auxiliary Payloads (ASAP) offered by Ariane 5 which delivers communication satellites to GEO. A launch

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from French Guiana, near the equator, would place the glider carrier into a geosynchronous transfer orbit (GTO) after the primary payload is dropped off at GEO (35900 km altitude). Compared with LEO, this higher energy orbit would, under ideal conditions, require the carrier to apply only 1200 m/s to escape to Mars in 2003, instead of 3500 m/s. However, conditions are not ideal, so a rather circuitous route must be taken.

The trajectory solution, which must allow a 2 to 3 month any-time Ariane launch prior to Earth escape to Mars, requires a 3-burn flight path which includes a lunar free and an Earth powered flyby. This will be discussed in more detail in the paper. The attached figure gives an example of the trajectory profile, where the first burn delivers the spacecraft beyond the Moon, the second at apogee targets a return path to a lunar flyby, and the third, close to Earth is the escape burn to Mars.

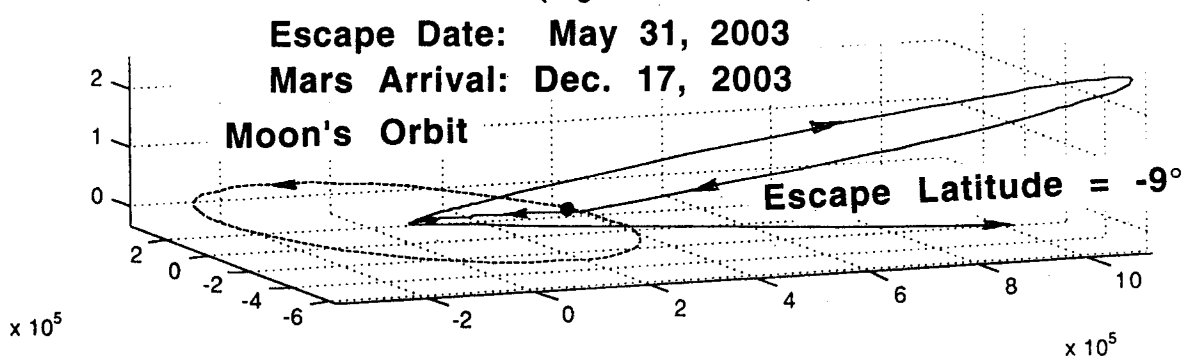
The remaining questions, discussed in detail in the paper, require optimizing the Earth-to-Mars trajectory to satisfy the complex arrival conditions. It is shown that only a 2-hour variation in arrival time at Valles Marineris is possible, and that the gliders must be capable of an azimuth change once they are released from the carrier. Also, the analysis shows that a planned Mars orbiter cannot be used as a relay for the gliders, and that the glider carrier can be made to pass above the glide path in such a manner that it can receive data from several gliders, and subsequently relay the data to Earth after it flies by Mars.

By a rare coincidence, the date selected for Mars arrival happens to be the 100th anniversary, to the day, of the Wright brothers Kittyhawk flight.

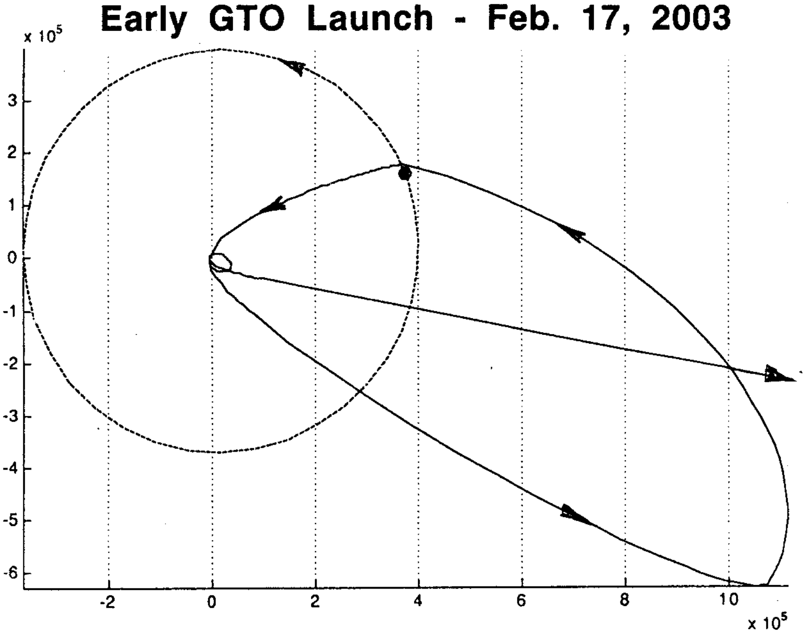
REFERENCE

1. Penzo, P. A., "Planetary Missions from GTO Using Earth and Moon Gravity Assists", Paper AIAA 98-4393, presented at the AIAA/AAS Astrodynamics Specialist Conference, Boston, MA, 10-12 August, 1998.

GTO TO MARS 2003 (C_3 = 9 km^2/s^2)



Early GTO Launch - Feb. 17, 2003



Late GTO Launch - May 3, 2003